It is recommended that, for application of TEELs, the concentration at the receptor point of interest be calculated as the peak 15-minute time-weighted average concentration. It should be emphasized that TEELs are default values, following the published methodology (on the SCAPA web page [DOE 2002]) explicitly.

F.2.3.1 Impacts from Industrial Accidents

Impacts of potential industrial and occupational accidents were predicted using five-year average statistics for the U.S. DOE Richland Operations Office, reported in Computerized Accident/Incident Reporting System, or CAIRS, for the years 1996 – 2000 (DOE 2001). The baseline statistics, applied separately for construction and operations activities, are presented in Section 4.10. Impacts are presented as the predicted number of total recordable cases, lost workday cases, lost workdays, and fatalities for construction and operation activities, based on the number of worker-years for that activity. A full-time worker is assumed to work 2,000 hours per year.

F.3 Intruder Impact Assessment Methods

In the assessment of intruder impacts, inadvertent intrusion is defined as an inadvertent activity that results in direct contact with the waste from a LLW disposal facility. Two types of inadvertent intrusions are considered: excavation of a basement for construction of a dwelling and drilling a well. In each case, the waste would be extracted from the disposal facility and the extracted waste, with the exception of activated metal and concrete (or grout), is assumed to be indistinguishable from soil. Pathways by which an intruder might be exposed to radiation from the exhumed waste include the following:

- ingestion of vegetables grown in the contaminated soil

- ingestion of soil

- inhalation of radionuclides on dust suspended in the air by gardening activities or wind

- external exposure to direct radiation from contaminated soil while working in the garden or residing in the house built on top of the waste disposal facility.

Calculations were performed via a spreadsheet using dose rate per unit concentration conversion factors contained in performance assessments for the disposal of LLW in the LLBGs and peak radionuclide concentrations (WHC 1995, 1998). Peak radionuclide concentrations are shown in Table F.48 along with a short description of the waste origin. The peak concentration values are based on information extracted from the Solid Waste Information Tracking System, or SWITS, database (Anderson and Hagel 1996; Hagel 1999) and decay corrected to 2046. These radionuclides would not all occur within the same waste container, or even within the same disposal facility. Therefore, the peak values represent a hypothetical maximum waste package.

Table F.48. Peak Radionuclide Concentrations in Disposal Facilities (Year 2046)

Radionuclide	Peak Waste Concentration, Ci/m^3	Probable Waste Description
Tritium	6.9E+02	Failed tritium targets
Carbon-14[(a)]	4.2E+0	Naval core basket
Cobalt-60[(a)]	5.1E-01	Naval core basket
Nickel-59[(a)]	5.9E+0	Naval core basket
Nickel-63[(a)]	4.9E+02	Naval core basket
Strontium-90	1.0E+03	B Plant filters during encapsulation of strontium fluoride
Technicium-99	7.9E-02	Discarded uranium oxide
Iodine-129	5.2E-03	PUREX debris
Cesium-137	4.1E+02	B Plant filters during encapsulation of cesium chloride
Uranium-234	2.4E-01	Discarded uranium oxide
Uranium-235	6.0E-02	Discarded uranium oxide
Uranium-236	2.5E-01	Discarded uranium oxide
Uranium-238	1.5E-01	Discarded uranium oxide
(a) The activity is in activated metal.		

F.3.1 Human Intrusion Exposure Scenarios

Estimation of impacts from inadvertent human intrusion that were considered in this analysis included the following hypothetical scenarios: well drilling, post-well drilling gardening, excavation, post-excavation gardening, and the deep-root garden. The parameters and values employed for radiation dose and associated impacts are presented as follows:

1. Well Drilling. A 30-cm (12-in.) diameter well is driven through the waste.

2. Post-Well Drilling Gardening. Waste from the well hole is mixed with topsoil in which vegetables are grown. The vegetables are consumed as well as incidental soil.

3. Excavation. 300 m^3 (11,000 ft^3) of waste is exhumed during construction of a nominal 139-m^3 (1500-ft^2) house with a basement.

4. Post-Excavation Gardening. Waste from the basement excavation is mixed with soil in which vegetables are grown. The vegetables are consumed as well as incidental soil.

5. Deep-Root Garden. Crop roots, including fruit and nut trees or other natural plant roots (such as alfalfa), penetrate the waste zone, thereby contaminating crops or fodder that are consumed in the human food chain.

For Category 1 LLW, waste is buried at a depth of about 3 m (10 ft) and would be accessible by excavation, drilling, or root penetration of fruit and nut trees and alfalfa. Thus, all five scenarios apply.

For Category 3 LLW, waste is buried at sufficient depth of 5 m (16 ft) or more to eliminate excavation for a dwelling house. However, root penetration by fruit and nut trees would still be possible as a feasible, but minor, means of interacting with the waste. WAC 173-340 states that for soil cleanup levels based on human exposure via direct contact, the point of compliance is established in the soils throughout the site from the ground surface to 3.8 m (15 ft) below the ground surface. This estimate represents a reasonable depth of soil that could be excavated and distributed at the soil surface as a result of site development activities.) Thus, only the drilling and post-drilling scenarios are applicable based on depth of the waste. However, Category 3 LLW is contained within concrete high-integrity containers (HICs) and is considered highly improbable that drilling through HICs would occur. Regardless, this scenario was selected to reasonably bound consequences of intrusion impacts from wastes under consideration in this HSW EIS.

Evaluation of this intrusion scenario was performed for 100, 500, and 1000 years after the year 2046. No allowance was given for the modified RCRA Subtitle C cover to be used in capping HSW disposal facilities in Alternative Groups A and B. Thus, the drilling scenario, as evaluated, applies to all alternative groups under consideration.

In the well drilling operation, 0.35 m^3 (12 ft^3) waste (from a 0.3-m [12-in.] diameter well assumed to be drilled through 5 m [16 ft] of waste) is brought to the surface and spread over a 2500-m^2 (0.6-ac) garden. The resulting redistribution factor results in a value of 1.4E-04 m^3 of waste per m^2 (4.6E-04 ft^3 of waste per ft^2). It is assumed the exhumed soil is thoroughly mixed to a depth of 15 cm (6 in.).

The area of the garden is a size that would reasonably supply the resident's vegetable diet (Napier et al. 1984) and has been used in other assessments (for example, Kincaid et al. 1995). The mixing depth of 15 cm (6 in.) is considered a typical plowing depth for most farming practices. An attempt was made to be reasonably conservative in the selection of values, so those dose estimates would be bounding.

Inhalation and external exposures are based on the following exposure times: the gardener is assumed to spend 1800 hr/yr outside in the garden and 4380 hr/yr inside. The remaining 2580 hr/yr are spent elsewhere on the property.

A mathematical model is used to calculate the amount of each radionuclide that is brought to the surface by human intrusion. Estimates of annual frequencies of yearly probabilities for borehole drilling into the disposal facility with the highest consequence impacts were calculated. The annual probabilities were derived by multiplying the annual borehole frequency per square kilometer, 0.01/km/yr, by the surface area occupied by the waste container. This value is more than three times higher than the number recommended by EPA in 40 CFR 191. For example, in 1976, a 48.9 m^3 box containing 100,000 curies of cesium-137 was disposed of in the 218-E-10 Burial Ground for a concentration of 2040 Ci/m^3 in HEPA filters from B-Plant. That concentration of cesium-137 would physically decay to a concentration of about 410 Ci/m^3 by 2046. This box was assumed to be cubical in shape and, therefore, approximately 3.66 m (12 ft) on a side. This provides an estimate of 13.4 m^2 (1.3E-05 km^2) of surface area for the container into which the borehole can be drilled. Thus the probability of randomly drilling into and hitting the container holding the highest radioactivity concentration of cesium-137 would be roughly 1.3E-07 per year.

F.3.2 Radiological Analysis

The dose-rate-per-unit waste concentration factors (mrem/yr per Ci/m^3) for 13 radionuclides are given in Table F.49 for the post-well drilling scenario and in Table F.50 for the excavation scenario. The analysis used the Kennedy and Strenge (1992) concentration ratios and assumed the intrusion to begin at 100, 500, and 1000 years after the year 2046. The dose-rate-per-unit waste concentration factors were evaluated by setting the initial concentration (that is, at year 2046) of a radionuclide in the waste to 1 Ci/m^3 and then evaluating the intruder scenario at the specified time. The evaluation was based on the amount of the radionuclide present at the specified time (and any progeny radionuclides that may have grown in from the parent radionuclide). The dose-rate-per-unit waste concentration factors were evaluated for all radionuclides assumed to be present in the waste streams contributing to disposal facility activity. The dose-rate-per-unit waste concentration factors were then multiplied by the given initial concentration of radionuclides of interest to estimate the final dose results. For given radionuclides, doses were calculated as a function of time, using the assumption of leaching or not leaching of radionuclides from the soil during crop growth. For each radionuclide, the exposure pathway providing the largest dose is also shown in the tables.

The dose-rate-per-unit waste concentration factors change with time because of decay of the parent radionuclide and leaching of radionuclides from the surface soil. The unit dose factors given in Tables F.49 and F.50 for *without soil leaching* are impacted only by radioactive decay and progeny

Table F.49. Dose-Rate-per-Unit Waste Concentration Factors (mrem/yr per Ci/m^3) for the Post-Well Drilling Scenario, Time Since Year 2046

Nuclide	Without Soil Leaching			Dominant Exposure Pathway
	100 yr	300 yr	500 yr	
Tritium	5.11E-06	6.39E-11	7.99E-16	Soil Ing.
Carbon-14	5.13E+0	5.01E+0	4.89E+0	Vegetable
Cobalt-60	6.26E-03	2.37E-14	8.96E-026	External
Nickel-59	1.19E-01	1.18E-01	1.18E-01	External
Nickel-63	7.85E-02	1.97E-02	4.92E-03	Vegetable
Strontium-90	3.00E+01	2.36E-01	1.85E-03	Vegetable
Technetium-99	2.00E+01	1.99E+01	1.99E+01	Vegetable
Iodine-129	5.47E+01	5.47E+01	5.47E+01	Vegetable
Cesium-137	8.45E+01	8.54E-01	8.63E-03	External
Uranium-234	5.25E+01	5.25E+01	5.25E+01	Inhalation
Uranium-235	1.70E+02	1.84E+02	1.98E+02	External
Uranium-236	4.91E+01	4.91E+01	4.91E+01	Inhalation
Uranium-238	8.18E+01	8.18E+01	8.18E+01	Inhalation

Table F.50. Dose-Rate-per-Unit Waste Concentration Factors (mrem/yr per Ci/m^3) for the Excavation Scenario, Time Since Year 2046

Nuclide	Without Soil Leaching			Dominant Exposure Pathway
	100 yr	300 yr	500 yr	
Tritium	1.09E-03	1.37E-08	1.71E-13	Soil Ing.
Carbon-14	1.10E+03	1.07E+03	1.05E+03	Vegetable
Cobalt-60	1.34E+0	5.07E-12	1.92E-023	External
Nickel-59	2.53E+03	2.53E+01	2.53E+01	External
Nickel-63	1.68E+01	4.21E+0	1.05E+0	Vegetable
Strontium-90	6.43E+03	5.05E+01	3.96E-01	Vegetable
Technetium-99	4.28E+03	4.27E+03	4.27E+03	Vegetable
Iodine-129	1.17E+04	1.17E+04	1.17E+04	Vegetable
Cesium-137	1.81E+04	1.83E+02	1.85E+0	External
Uranium-234	1.13E+04	1.12E+04	1.12E+04	Inhalation
Uranium-235	3.63E+04	3.94E+04	4.25E+04	External
Uranium-236	1.05E+04	1.05E+04	1.05E+04	Inhalation
Uranium-238	1.75E+04	1.75E+04	1.75E+04	Inhalation

ingrowth. These dose factors generally decrease with time as the parent decays, although progeny ingrowth may cause an increase with time. For example, the uranium-235 dose-rate–per-unit waste concentration factors increase with time because of the ingrowth of protactinium-231. The dose-rate-per-unit waste concentration factors for *with soil leaching* are impacted by decay and leaching and are less than or equal to the corresponding value for no leaching.

F.4 Impacts from Waterborne Pathways

This section presents additional results to those presented in Section 5.11 for the groundwater analyses, including examples of contributions to impacts by waste type and radionuclide and summaries of potential impacts to the resident gardener at the 1-km points of analysis and the Columbia River point of analysis for all alternative groups.

Graphs of contributions to drinking water dose by radionuclide are presented in the following figures for all alternative groups and for the Hanford Only and Upper Bound waste volumes. For the No Action Alternative, the results are presented only for only for the Hanford Only waste volume, as the results are very similar to those for the Lower Bound waste volume. The content for each figure is indicated in Table F.51.